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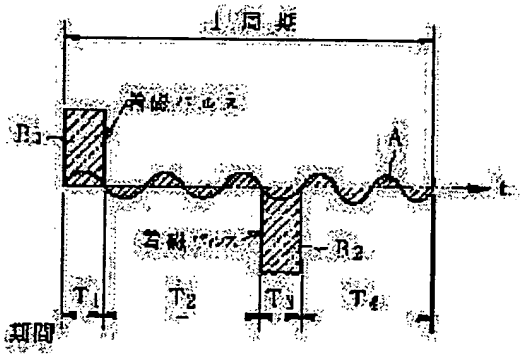
(54) DC CURRENT SENSOR

(57)Abstract:
PROBLEM TO BE SOLVED: To shorten a measuring time of a DC current flowing to a lead to be detected by preventing an influence of a coercive force of a soft magnetic material of a detecting core, and assuring detection of high sensitivity even in an infinitesimal current range of several mA in a DC current sensor having the core made of a soft magnetic material formed in an annular state, a detecting coil wound and disposed in a toroidal state on the core, and a means for periodically forming a magnetic gap at least at part of the circumferential direction of the core.
SOLUTION: A detecting core is once alternately magnetized by a magnetizing pulse having a positive side or negative side symmetrical waveform for giving a magnetic field exceeding a coercive force Hc. Then, when a DC current flowing the a lead to be detected is superposed and measured in the state that alternating magnetic field is continuously given to a modulation coil in a range of the coercive force or less of the core, complete demagnetization is not conducted. Even in an incompletely demagnetized state, when the DC current flowing to the lead to be detected is measured based on a mean value of measured result after the magnetization, the substantially same effect as that for erasing a hysteresis is obtained.



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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to amelioration of the direct-current sensor arranged by the device which uses various kinds of direct current, and relates to the direct-current sensor which it is effective in applications, such as ground failure detection of the direct current circuit especially used for the control facility of ** and a substation, and fault current detection of a solar-battery generation-of-electrical-energy system, and is high sensitivity, and enabled compaction of measurement time amount substantially.
[0002]
[Description of the Prior Art] From the former, the shunt resistance method, the magamp method, the magnetic multivibrator method, the hall device method, etc. are learned as a direct-current sensor. However, the actual condition is these direct-current sensors' being hard to be called structure where it can respond to a minute current change structure's being not only complicated, but, and having not resulted in practical use as a direct-current sensor of high sensitivity.
[0003] The invention-in-this-application person proposed the direct-current sensor by which structure consists of completely different structure from the conventional method as a direct-current sensor of the high sensitivity which has the ability to detect which is comparatively easy and was excellent also to a minute current change previously in view of such the actual condition (JP,6-74978,A, JP,6-194389,A, JP,6-281674,A, JP,7-49357,A, JP,7-55846,A, JP,7-110343,A, JP,7-198754,A).
[0004] Namely, the detection core section which consists of a soft magnetic material which forms annular and the sensing coil by which winding arrangement is carried out in the detection core section at the shape of toroidal one, It is the direct-current sensor which considers the configuration possessing a means to form a magnetic gap in a part of hoop direction [at least] of said detection core section periodically as a basic configuration. Penetration arrangement of the detected lead wire was carried out inside the detection core section which constitutes this direct-current sensor, and it made it possible to measure the direct current which flows to a detected lead wire to high sensitivity.
[0005] In order to realize detection in a minute current field to high sensitivity especially It is required to decrease the hysteresis phenomenon of the output voltage (output characteristics) from the sensing coil resulting from the effect of the coercive force which the soft magnetic material which constitutes the detection core section has. The modulation coil made to wind around said detection core section in a detected lead wire and this direction is arranged. The direct-current sensor (JP,6-281674,A) of a configuration of measuring the direct current which flows to a detected lead wire was proposed superimposing the alternating field which generated this modulation coil on the detection core section, and the object was attained.
[0006] For example, the detection core section 2 which the direct-current sensor shown in drawing 6 becomes from the soft magnetic material which forms annular, The excitation core section 4 which consists of a soft magnetic material which connects with the shape of toroidal one in the rectangular direction to the hoop direction of the detection core section 2 which are the sensing coil 3 by which

winding arrangement is carried out, and a means to form a magnetic gap in a part of hoop direction [at least] of said detection core section 2 periodically, and forms annular in the detection core section 2, An exiting coil 5 by which winding arrangement is carried out, and a modulation coil 43 made to wind further at the detection core section 2 are consisted of by the excitation core section 4 at the shape of toroidal one. One in drawing is a detected lead wire which carries out penetration arrangement inside the detection core section 2.

[0007] In such a configuration, if a direct current I flows to the detected lead wire 1, a clockwise magnetic field will occur to the direction of a direct current I in the detection core section 2, and magnetic flux phi 0 will occur in the detection core section 2. If the magnetic flux which energizes predetermined alternating current to an exiting coil 5, and changes to the excitation core section 4 in the direction of alpha in drawing periodically at this time is generated and this excitation core section 4 is saturated magnetically periodically Relative permeability mu reaches to an extreme of the core intersection 6 which is a part of hoop direction of the detection core section 2, and it decreases the so-called substantial magnetic gap and the magnetic flux phi 0 in the detection core section 2 near 1 even to phi 1 (phi1 approximation 0).

[0008] Here, when the alternating current energized to an exiting coil 5 is made into a frequency f0 and it is made for the excitation core section 4 to be saturated near the peak value of the current, the excitation core section 4 will be saturated twice exciting-current 1 period. That is, the core intersection 6 which is a part of hoop direction of the detection core section 2 will be saturated, 2f of direct current I which flows to the detected lead wire 1 will become irregular by 0, and the electrical potential difference VDET of 0 will generate according to them the magnetic flux phi 0 generated in the detection core section 2 in a sensing coil 3 the frequency of 2f with change of the above-mentioned magnetic flux phi 0.

[0009] Irrespective of the sense of the direct current I which flows to the detected lead wire 1, in any case, it becomes an electrical-potential-difference VDET** direct current I from the relation between a magnetic-flux phi0** direct current I and the electrical-potential-difference VDET** magnetic flux phi 0, and it becomes possible [detecting the electromotive force proportional to the direct current I which flows to the detected lead wire 1 with a sensing coil 3].

[0010] However, in detection in a minute current field, the inversion field (field where output voltage decreases with the increment in a direct current) accompanying the hysteresis phenomenon of the output voltage (output characteristics) from the sensing coil resulting from the effect of the coercive force which the soft magnetic material which constitutes the detection core section 2 has cannot occur, fluctuation of the reference level at the time of measurement cannot be caused as a result, and detection of high sensitivity made into the object cannot be realized.

[0011] In the configuration of drawing 6 , in order to attain reduction of the above-mentioned hysteresis phenomenon, the modulation coil 43 made to wind around the detection core section 2 in the detected lead wire 1 and this direction has been arranged, and detection of high sensitivity was realized by measuring the direct current which flows to the detected lead wire 1, superimposing the alternating field which generated this modulation coil 43 on the detection core section 2.

[0012] Namely, the detection core section 2 which has BH curve (hysteresis curve) as shown in drawing 7 is received. A direct current to the detected lead wire 1, without passing modulation alternating current in the modulation coil 43 For example, a sink, After reaching to P points on BH flat surface, if a direct current is cut, it will return to A' point. Further If modulation alternating current required to generate the magnetic field beyond the coercive force of the detection core section 2 in the modulation coil 43 is passed from this condition, it will follow on the shift to A->B->C->D->E of an alternating current wave. BH curve top -- A'->B' ->C -- it will shift to '->D'->E' and the minor loop Q henceforth shown with the broken line in the same root, i.e., drawing, will be drawn.

[0013] The core of this minor loop Q is in agreement with the zero O of BH curve. Since the same phenomenon is indicated to be the above to the detected lead wire 1 even when the direct current of the reverse sense is passed, if modulation alternating current passes in the modulation coil 43 and modulation alternating current superimposes on a measured current in the condition that a direct current

is flowing to the detected lead wire 1, as shown in drawing 8 , while the core X of a minor loop Q had maintained the configuration of a minor loop Q according to the sense of the current of the detected lead wire 1, it will move along with the broken line in drawing. Therefore, it can measure in the condition of having disappeared the hysteresis substantially, by detecting this point (core X). It is removing the modulation alternating current component on which it was superimposed in the detector on the occasion of actual measurement, and the direct-current component which is flowing to the detected lead wire 1 can be easily detected by high sensitivity.

[0014] The configuration with the fundamental direct-current sensor shown in drawing 9 is the same as that of the direct-current sensor shown in drawing 6 , and it also has the demagnetization effectiveness of the detection core section 2 by this exiting coil 5 by carrying out winding arrangement of the exiting coil 5 especially in the hoop direction of the detection core section 2. Also in this configuration, a working principle from it being the same as that of the direct-current sensor shown in drawing 6 By arranging the modulation coil 43 made to wind around the detection core section 2 in the detected lead wire 1 and this direction, and measuring the direct current which flows to the detected lead wire 1 while the alternating field which generated this modulation coil 43 are superimposed on the detection core section 2 The effect of the coercive force which the soft magnetic material which constitutes the detection core section 2 has can be reduced.

[0015] The detection core section 2 which the direct-current sensor shown in drawing 10 becomes from the soft magnetic material with which the sensor section forms annular, The sensing coils 3a and 3b of the couple by which winding arrangement is carried out in the object location of the detection core section 2 at the shape of toroidal one, The excitation core sections 4a and 4b of the couple which consists of a soft magnetic material which connects in the rectangular direction to the hoop direction of said detection core section 2, and forms annular, It consists of an exiting coil 5 which winding arrangement is carried out at the detection core section 2, and excites the detection core section 2 periodically in the rectangular direction to a hoop direction in the rectangular section 6 of this detection core section 2 and each excitation core sections 4a and 4b.

[0016] Moreover, the detection core section 2 which the direct-current sensor shown in drawing 11 becomes from the soft magnetic material with which the sensor section forms annular, The sensing coils 3a and 3b of the couple by which winding arrangement is carried out at the position of symmetry of the detection core section 2 at the shape of toroidal one, The excitation core sections 4a and 4b of the couple which consists of a soft magnetic material which connects in the rectangular direction to the hoop direction of said detection core section 2, and forms annular, It consists of exiting coils 5a and 5b which winding arrangement is respectively carried out in the outside surface part of the excitation core sections 4a and 4b, and excite the detection core section 2 periodically in the rectangular direction to a hoop direction in the rectangular section 6 of this detection core section 2 and each excitation core sections 4a and 4b.

[0017] From the overall configuration of both the sensor sections being symmetrical to the detected lead wire 1, the direct-current sensor shown in these drawing 10 and drawing 11 has good electromagnetism-balance, and has the effectiveness that the stable measurement is realizable. Also in these configurations, a working principle from it being the same as that of the direct-current sensor shown in drawing 6 The modulation coils 43a and 43b made to wind around the detection core section 2 in the detected lead wire 1 and this direction are arranged. The effect of the coercive force which the soft magnetic material which constitutes the detection core section 2 has can be reduced by measuring the direct current which flows to the detected lead wire 1, superimposing the alternating field which generated these modulation coils 43a and 43b on the detection core section 2.

[0018]

[Problem(s) to be Solved by the Invention] As explained above, according to the direct-current sensor (JP,6-281674,A) which the invention-in-this-application person proposed previously, the effect of the coercive force which the soft magnetic material which constitutes the detection core section has could be prevented, and it became possible to also realize detection in a minute current field to high sensitivity. However, when the direct current which flows to a detected lead wire was about several mA, it was

difficult to secure detection of the high sensitivity demanded not necessarily.
[0019] For example, Permalloy C (78nickel-3.5Cu-4.5 Mo-balFe) is used as a soft magnetic material which constitutes the detection core section. In order to prevent the effect of the coercive force (Hc approximation 0.01Oe) of this permalloy C in the case of the direct-current sensor of drawing 10 which set the die length (magnetic-path length) of the hoop direction of the detection core section to 100mm It is necessary for a modulation coil to measure the direct current which flows the modulation alternating current of peak value extent of **100mA (70mArms) to a detected lead wire with a sink at least.
[0020] It becomes impossible therefore, to design a detector so that it may not be electrically saturated with the input of **100mA, to be the same as measuring several mA with an ammeter with a rating of 100mA as a result, and to separate easily the signal equivalent to modulation alternating current, and the signal equivalent to a measured current from the signal acquired from the sensing coil, but to secure the target accuracy of measurement (sensibility).
[0021] Moreover, the measurement of the direct current which, as for the output from a detector, only saturation power is obtained even if a detector will be electrically saturated with the signal of modulation alternating current since maximum input voltage is small if the detector of high sensitivity is used, and the signal of a measured current is inputted, and cannot identify the signal of a measured current, but flows to a detected lead wire itself becomes difficult.
[0022] This invention aims at offer of the direct-current sensor which made it possible to secure detection of high sensitivity also in an about several mA minute current field while it prevents the effect of the coercive force which the soft magnetic material which constitutes the detection core section especially for the purpose of solving the above-mentioned problem has. Moreover, the measuring time of the direct current which flows to a detected lead wire is shortened, and it aims at offer of the direct-current sensor which enabled improvement in a speed of response.
[0023]
[Means for Solving the Problem] In order for this invention to eliminate the effect of the coercive force which the soft magnetic material which constitutes the detection core section has and to enable detection of minute current field appearance, After magnetizing by the magnetization pulse which has the necessary wave which can give the field which once exceeds coercive force (Hc) for the detection core section as a result of examining many things, Where the modulation alternating current which gives alternating field continuously to a modulation coil in the range below the coercive force of the detection core section is impressed When the direct current which flows to a detected lead wire is superimposed and measured, even if perfect demagnetization cannot be performed but it is in an imperfect demagnetization condition if the direct current which flows to a detected lead wire based on the measurement result of these each after magnetization is measured, if a hysteresis is eliminated substantially, the knowledge of the same effectiveness being acquired will be carried out, and it will complete.
[0024] If it explains in full detail, in order to give the field exceeding the coercive force (Hc) which this invention arranges the modulation coil made to wind around the detection core section of the direct-current sensor of said configuration in a detected lead wire and this direction, and the soft magnetic material of the detection core section has, Periodical, independent [which has a forward side and/or the symmetry of a negative side, or an unsymmetrical wave in arbitration], or after impressing one magnetization pulse of the patterns variously, The modulation alternating current for giving alternating field continuously to this modulation coil in the range below the coercive force (Hc) which the aforementioned soft magnetic material has is impressed. Said modulation alternating current and the direct current which flows to a detected lead wire are superimposed and measured, and the true direct current which flows to a detected lead wire based on the measurement result is measured.
[0025] Namely, the detection core section which consists of a soft magnetic material with which the invention in this application forms annular, In the direct-current sensor which comes to carry out penetration arrangement of the detected lead wire inside the sensor section which possesses the sensing coil by which winding arrangement is carried out, and a means to form a magnetic gap in a part of hoop direction [at least] of said detection core section periodically, in the shape of toroidal one at the

detection core section It has the modulation coil made to wind around said detection core section in a detected lead wire and this direction. After impressing the magnetization pulse which gives the field exceeding the coercive force (Hc) which the soft magnetic material of the detection core section has at least, The modulation alternating current for giving alternating field continuously to this modulation coil in the range below the coercive force (Hc) which the aforementioned soft magnetic material has is impressed. It is the direct-current sensor which has a means to superimpose and measure said modulation alternating current and the direct current which flows to a detected lead wire, and to measure the true direct current which flows to a detected lead wire based on the measurement result.
[0026] Moreover, the detection core section which the direct-current sensor characterized by sharing the function of a sensing coil and a modulation coil with one coil in the above-mentioned configuration and the sensor section turn into from the soft magnetic material which forms annular, The excitation core section of the couple which consists of a soft magnetic material which connects with the shape of toroidal one in the rectangular direction to the sensing coil by which winding arrangement is carried out, and the hoop direction of said detection core section, and forms annular in the detection core section, the direct-current sensor characterized by consisting of an exiting coil which winding arrangement is carried out at the excitation core section of each this or the detection core section, and excites the detection core section periodically in the rectangular direction to a hoop direction in the rectangular section of the detection core section and each excitation core section is proposed collectively.
[0027]
[Embodiment of the Invention] In the direct-current sensor of this invention, it is not limited to the configuration which the soft magnetic material has to the shape of so-called ring to consist of a soft magnetic material with which the detection core section and the excitation core section form annular, but various configurations, such as the shape of a circle, ellipse annular, and a rectangle frame, can be adopted like drawing 6 explained previously, drawing 9 , drawing 10 , and drawing 11 that what is necessary is just to connect so that a soft magnetic material can constitute an electromagnetism-closed circuit.
[0028] moreover -- although viewpoints, such as magnetic properties and workability, to a permalloy is usually desirable as a soft magnetic material which constitutes the detection core section and the excitation core section -- in addition, a silicon steel plate, amorphous one, and electromagnetism -- well-known ingredients, such as soft iron and a soft ferrite, are usable.
[0029] furthermore, a modulation coil as carrying out winding arrangement in a detected lead wire and this direction in the detection core section in the direct-current sensor of the invention in this application As are shown in drawing 6 explained previously, drawing 9 , drawing 10 , and drawing 11 , and it penetrates in a detected lead wire and this direction inside the detection core section, carry out winding arrangement of the modulation coil of 1 turn, and also According to the reinforcement of the demagnetization field by the damping-oscillation current demanded etc., winding arrangement of the modulation coil of two or more turns in the above and this direction will be carried out, and winding arrangement especially of the case of two or more turns will be substantially carried out in the detection core section like a sensing coil at the shape of toroidal one. Moreover, since winding arrangement of a modulation coil and the sensing coil is substantially carried out in the same direction in the same location, these can be shared, and even if it adopts the configuration which unified the modulation coil and the sensing coil, the object of this invention can be attained.
[0030] It explains based on one example which shows an operation of the direct-current sensor of this invention to drawing 1 - drawing 11 . The configuration of the sensor section may be equivalent to drawing 6 explained previously and the configuration shown in drawing 9 - drawing 11 . While impressing here the modulation alternating current which gives alternating field continuously in the range below the coercive force (Hc) which the soft magnetic material which forms the detection core section has to a modulation coil The magnetization pulse which has the symmetrical wave of the forward side which gives the field exceeding the coercive force (Hc) which this soft magnetic material has periodically, or a negative side is impressed by turns. after impressing a magnetization pulse respectively, a means to superimpose and measure said modulation alternating current and the direct

current which flows to a detected lead wire, and to measure the direct current which flows to a detected lead wire based on the average of the measurement result of these each is explained.
[0031] Drawing 1 shows the relation of the current and time amount which are impressed to a modulation coil, and drawing 2 shows the migration situation on BH curve corresponding to drawing 1 . As the condition that the measured current is not flowing is shown in a detected lead wire at drawing 1 , the modulation alternating current A which gives alternating field continuously in the range below the coercive force which the soft magnetic material with which peak value constitutes the detection core section has is first impressed to a modulation coil. Moreover, this modulation alternating current A needs to set up a detector in the range which is not saturated electrically.
[0032] In such a condition, the magnetization pulse B1 by the side of forward [which gives the field exceeding the coercive force (Hc) which the soft magnetic material with which only the period of T1 constitutes the detection core section in drawing 1 has] is impressed. Since modulation alternating current A is given continuously, after the location on BH curve goes via **, it moves to ** by impression of said this magnetization pulse, and after magnetization pulse B1 impression draws a minor loop Q1.
[0033] Magnetization pulse B-2 of the negative side in which only the period of T3 has said magnetization pulse B1 and a symmetrical wave in drawing 1 after predetermined time progress is impressed. Since modulation alternating current A is given continuously, after the location on BH curve goes via ** further, it moves to ** by impression of said this magnetization pulse, and after magnetization pulse B-2 impression draws a minor loop Q2.
[0034] the each central point of a minor loop Q1 and a minor loop Q2 is equivalent to residual magnetic flux density +Br1' with an equal absolute value, and -Br2', respectively. since it generates similarly, in drawing 1 , modulation alternating current and the direct current which flows to a detected lead wire are superimposed and measured at the period of T2 and T four, mutual residual magnetic flux density +Br1' and -Br2' are negated as a result with outputting the average of the measurement result of these each, and the offset output of the above-mentioned phenomenon is lost also in the condition that the measured current is flowing to a detected lead wire.
[0035] In addition, since a detector will be electrically saturated if these magnetization signals are inputted into a detector, the period (it sets to drawing 1 and is the period of T1 and T3) which impresses the magnetization pulse B1 by the side of forward and magnetization pulse B-2 of a negative side separates the sensing coil from the detector so that a magnetization signal may not be inputted into a detector. The same is said of the configuration which shared the modulation coil and the sensing coil. After the above-mentioned magnetization is completed, the direct current which connects a detector with a sensing coil and flows to a detected lead wire is measured.
[0036] In the direct-current sensor which consists of the above configuration, the effect of a hysteresis can be prevented nearly thoroughly and detection of high sensitivity can be secured also in the about several mA minute current field made into the object. Moreover, since a magnetization pulse can be impressed in a short time, the measuring time-ed becomes short and a speed of response becomes early.
[0037] Moreover, in drawing 1 , although the configuration which impressed by turns the pulse which has the symmetrical wave of a negative side a forward side explained the magnetization pulse, it is not limited to this configuration. That is, as well as the case of a forward negative side symmetrical-wave form if the field to which the current value of a magnetization pulse exceeds the coercive force (Hc) of the soft magnetic material which constitutes the detection core section can be given and that current value does not have specific value appearance, the residual magnetic flux density on BH curve shown in drawing 2 (+Br, -Br) becomes the same substantially, and can attain the object of this invention.
[0038] If the field which follows, for example, exceeds coercive force (Hc) can be given, it will also be possible to make the magnetization pulse B-2 wave height (current value) of a negative side highly (greatly) or lower (small) than a forward side, and it will not be limited to a symmetrical wave by positive/negative. What is necessary is for modulation alternating current to be the range below the coercive force (Hc) of the soft magnetic material which constitutes the detection core section, and to be able to give alternating field and just to select it suitably in consideration of the capacity of a detector

within the limits of the current value of a measurement schedule. Moreover, if a period is measurable time amount, it does not need to set up long time amount on precision. In order to realize measurement of high degree of accuracy especially, grant of stable alternating field with little fluctuation of a current value (peak value) is desired.

[0039] In addition, although it is necessary to impress modulation alternating current continuously during the measurement after magnetization pulse impression, it is simultaneously impressed at the time of magnetization pulse impression, and there is not necessarily no need. Although the object can be attained even if it impresses continuously from before magnetization pulse impression, it is desirable to set up an impression means configuration in consideration of the configuration of an attached electrical circuit.

[0040] The magnetization pulse shown in drawing 3 A is what impressed magnetization pulse B-2 of a negative side to the forward side in the pattern which impressed the wave symmetrical with a negative side by turns the forward side of drawing 1 , each magnetization pulse shown in drawing 3 B is impressed to a negative side, and 2nd magnetization pulse B-2 is impressing the thing higher than the wave height (current value) of the previous pulse B1. Any magnetization pulse exceeds the current value which can give the field exceeding the coercive force (Hc) shown with a fictitious outline. Furthermore, it can also consider as impression of only the magnetization pulse B1 of drawing 3 A or drawing 3 B.

[0041] The impression pattern of drawing 1 can amend dispersion in the property of a soft magnetic material periodically, and has the advantage whose accuracy of measurement improves. The impression pattern of drawing 3 can do the measuring time comparatively short, becomes easier [a sequence] than the case of drawing 1 , and has the advantage whose zero-point drift of the measurement output by fluctuation of a residual magnetic flux density is lost substantially. Moreover, the measuring time is short, a forward side or in the unit impression to a negative side, it is easy a sequence, and it has the advantage which can simplify and miniaturize the configuration of a measuring instrument.

[0042] Periodically, it can be impressed by impression by turns, the pulse which, in short, gives the field exceeding the coercive force (Hc) of a soft magnetic material can be impressed to a forward side a forward side, at a negative side only at a chisel or a negative side, in mutual impression, the operation of each of these measurement results calculates the average, and, in single-sided impression, it is possible to carry out a total operation and to output the output equivalent to a residual. Even if not still more nearly periodical, after detecting that could impress the unit pulse to the forward side or the negative side, for example, the sensor output was saturated with the power up of measurement, the time of initialization, or an eddy current, an unit pulse is impressed, and single-sided impression of the above can be calculated and it can output.

[0043]

[Example] In order to check the effectiveness of the direct-current sensor of the invention in this application, the direct-current sensor which consists of a configuration shown in drawing 10 was created. the sensor section pierces and makes a predetermined configuration 0.2mm permalloy C (78nickel-3.5Cu-4.5 Mo-balFe) sheet metal, bending processing is performed, and the dimension of each core section is set to L= 30mm and H= 10mm W 1= 25mm W 2= 2.5mm -- as -- an assembly -- further, in the hydrogen gas ambient atmosphere, by 1100 degrees C, magnetic annealing of 3 hours was given and it completed.

[0044] Moreover, while carrying out 30 turn winding arrangement of the enameled wire with an outer diameter of 0.3mm as an exiting coil at the periphery of the detection core section, as a sensing coil (it uses with a modulation coil in common), winding arrangement of the 60 turns [every] enameled wire with an outer diameter of 0.2mm was carried out respectively, the series connection was mutually carried out to the position of symmetry of the detection core section, it connected with the detector which shows these coils in the block diagram of drawing 4 , and the direct-current sensor by this invention was completed. As a detected lead wire, penetration arrangement of the vinyl coating line with an outer diameter of 8mm was carried out inside the detection core section. The alternating current impressed to an exiting coil could be 1Vrms and 250Hz.

[0045] The modulation alternating current continuously impressed to a modulation coil (sensing coil)

could be 1.2Vrms and 62.[redacted]. Furthermore, the magnetization pulse [redacted]eriodically impressed to a sensing coil (modulation coil) is **15V, and impression time amount was considered as a part for 1/2 period of modulation alternating current. Therefore, the periods of about 8 msec(s), T2, and T four are about 80 msec(s) respectively, and the period of T1 and T3 in drawing 1 has checked that it was possible to complete measurement in 0.2 or less seconds. In addition, close and the output characteristics of a detector lump are shown in drawing 5 . It has checked that measurement of high sensitivity was very possible from drawing 5 .

[0046]

[Effect of the Invention] While preventing the effect of the coercive force which the soft magnetic material which constitutes the detection core section in the direct current sensor of this invention by impressing effectively a predetermined magnetization pulse and modulation alternating current to a sensing coil (modulation coil) has and realizing measurement of high sensitivity so that clearly also from the above-mentioned example , it becomes possible to shorten the measuring time substantially , and the application of a direct current sensor can be expand further .

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the line chart which shows the relation of the current and time amount which are impressed to a modulation coil which shows the outline of the measuring method of the direct-current sensor by this invention.
[Drawing 2] It is the line chart which shows the migration situation on BH curve corresponding to drawing 1 which shows the relation of the current and time amount which are impressed to a modulation coil.
[Drawing 3] It is the line chart which shows the relation of the current and time amount which are impressed to a modulation coil which shows the outline of other measuring methods of the direct-current sensor by this invention.
[Drawing 4] It is the circuit diagram of the measuring device used for the measuring method of the direct-current sensor by this invention.
[Drawing 5] It is the graph which shows the relation between a penetration current and output voltage.
[Drawing 6] It is the strabism explanatory view showing the basic configuration of the direct-current sensor of this invention.
[Drawing 7] After not passing modulation alternating current in a modulation coil, but passing a direct current to a detected lead wire and exciting a core, it is the line chart which shows the condition of having cut this direct current, having passed alternating current in the modulation coil after that, and having formed the minor loop.
[Drawing 8] It is in the condition that a direct current is flowing to a detected lead wire, and is the line chart which shows the migration condition of the central point of the minor loop at the time of passing modulation alternating current in a modulation coil, and superimposing the alternating current for a modulation on a measured current.
[Drawing 9] It is the strabism explanatory view showing the outline of other examples of the direct-current sensor of this invention.
[Drawing 10] It is the strabism explanatory view showing the outline of other examples of the direct-current sensor of this invention.
[Drawing 11] It is the strabism explanatory view showing the outline of other examples of the direct-current sensor of this invention.
[Description of Notations]
1 Detected Lead Wire
2 Detection Core Section
3, 3a, 3b Sensing coil
4, 4a, 4b Excitation core section
5, 5a, 5b Exiting coil
6 Core Rectangular Cross Section
43, 43a, 43b Modulation coil

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CLAIMS

[Claim(s)]
[Claim 1] The detection core section which consists of a soft magnetic material which forms annular, and the sensing coil by which winding arrangement is carried out in the detection core section at the shape of toroidal one, In the direct-current sensor which comes to carry out penetration arrangement of the detected lead wire inside the sensor section possessing a means to form a magnetic gap in a part of hoop direction [at least] of said detection core section periodically It has the modulation coil made to wind around said detection core section in a detected lead wire and this direction. After impressing the magnetization pulse which gives the field exceeding the coercive force (Hc) which the soft magnetic material of the detection core section has at least, The modulation alternating current for giving alternating field continuously to this modulation coil in the range below the coercive force (Hc) which the aforementioned soft magnetic material has is impressed. The direct-current sensor which has a means to superimpose and measure said modulation alternating current and the direct current which flows to a detected lead wire, and to measure the true direct current which flows to a detected lead wire based on the measurement result.
[Claim 2] The direct-current sensor according to claim 1 characterized by sharing the function of a sensing coil and a modulation coil with one coil.
[Claim 3] The detection core section which the sensor section turns into from the soft magnetic material which forms annular, The excitation core section of the couple which consists of a soft magnetic material which connects with the shape of toroidal one in the rectangular direction to the sensing coil by which winding arrangement is carried out, and the hoop direction of said detection core section, and forms annular in the detection core section, the direct-current sensor according to claim 1 characterized by consisting of an exiting coil which winding arrangement is carried out at the excitation core section of each this, or the detection core section, and excites the detection core section periodically in the rectangular direction to a hoop direction in the rectangular section of the detection core section and each excitation core section.

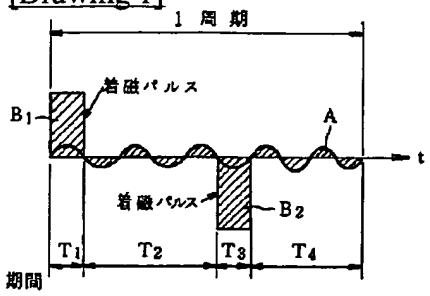
[Translation done.]

* NOTICES *

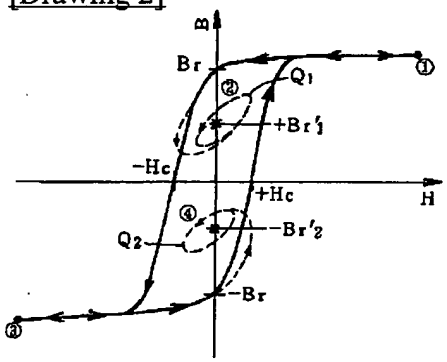
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

[Drawing 1]



[Drawing 2]



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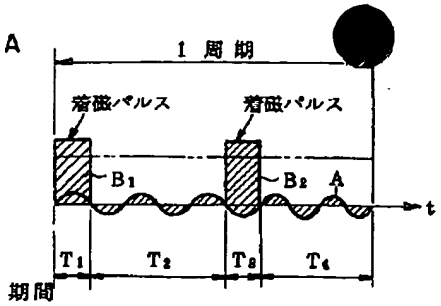
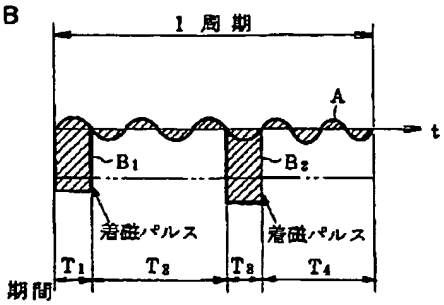
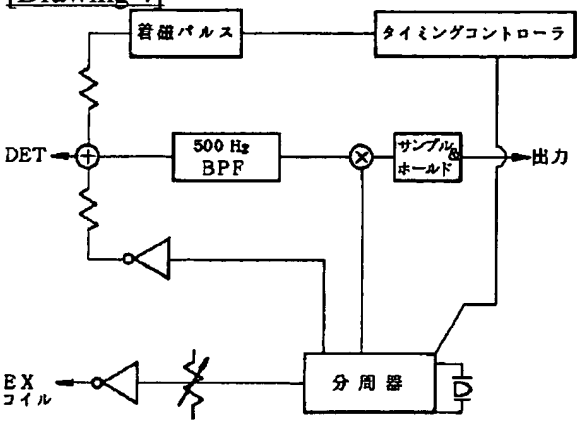
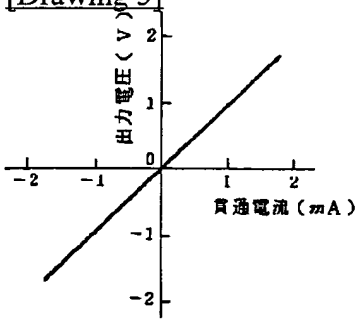




[Drawing 4]



[Drawing 5]



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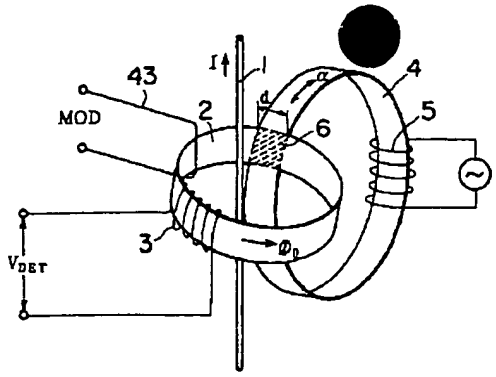
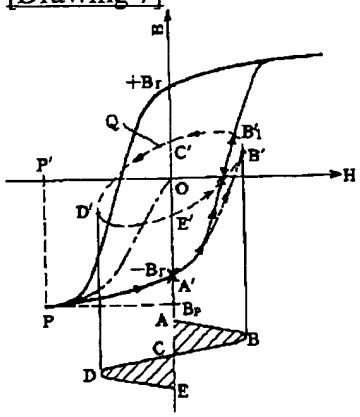
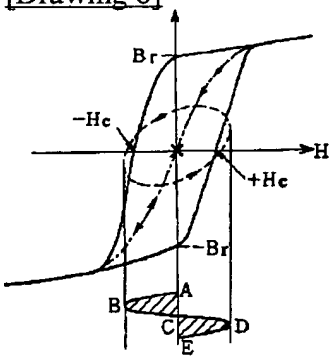


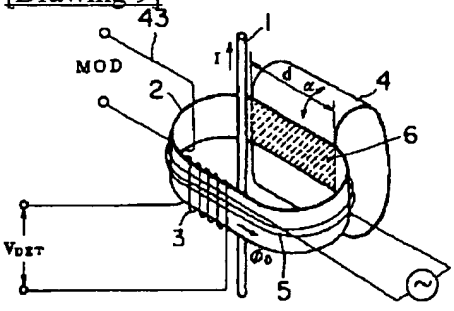
[Drawing 7]



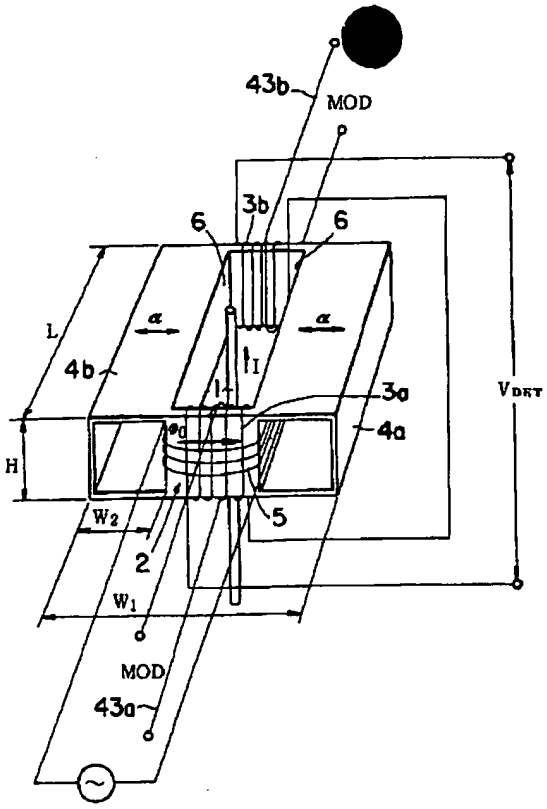
[Drawing 8]



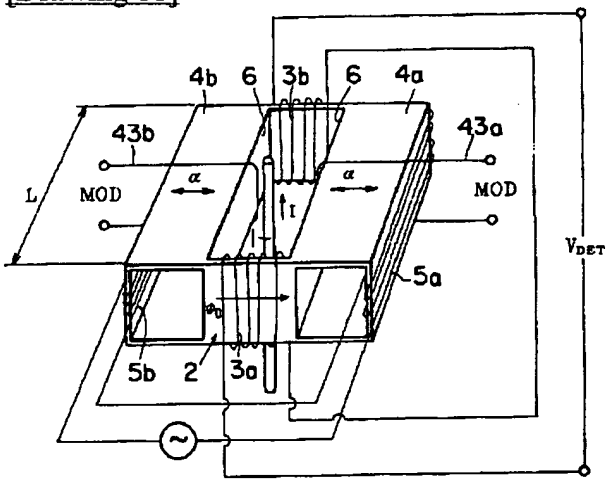
[Drawing 9]



[Drawing 10]



[Drawing 11]



[Translation done.]